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A METHOD TO CONVERT TWO-DIMENSIONAL MOTION PICTURES FOR THREE-DIMENSIONAL SYSTEMS

TECHNICAL FIELD

The invention relates to a method for converting existing film or videotape motion pictures to a form that can be used with three-dimensional systems for broadcast or exhibition.

BACKGROUND ART

With the advent of stereophonic sound, various techniques were developed to convert or 're-process' existing monophonic programs for stereophonic broadcast or recording systems. These included modifying the equilization, phase or tonal qualities of seperate copies of the monophonic program for the left and right channels. While true stereophonic or binaural effects may not have been

achieved, the effects were much improved over feeding the identical monophonic signal to both channels.

Similarly, with the almost universal use of color production, exhibition and broadcast systems for motion picures and television, systems have been developed to convert existing monochrome or black & white materials to color programs. Such a system is described in applicant Geshwind's patent number 4,606,625, issued August 19, 1986. The results of these colorized products, while not always identical to true color motion pictures, are more suitable than black & white for color systems.

There have been a number of systems for exhibition or display of left- and right-eye pairs of binocular motion pictures. Early systems reqired two completely redundant projection or display systems; e.g. two film projectors or CRT television displays, each routed to one eye via mirrors. Other systems require either complicated and expensive projection or display sytems, or expensive 'glasses' to deliver two seperate images. For example:

red- and green-tinted monochrome images are both projected or displayed to be viewed through glasses with left and right lenses tinted either red or green;

two full-color images are projected through mutually perpendicular polorized filters and viewed through glasses with lenses that are also polarized in the same manner;

left and right images are displayed on alternate odd and even fields (or frames) of a standard (or high scan rate) television CRT and are viewed through 'glasses' with shutters (either rotating blades or flickering LCDs, for example) that alternate the view of left and right eyes in synchrony with the odd or even fields of the CRT.

Of the above systems, the second is not at all usable with standard home television receivers, the third requires very expensive 'glasses' and may flicker with standard home receivers, and the first produces only strangly tinted monochrome images. Further, none of the systems may be broadcast over standard television for unimpeded viewing without special glasses.

Thus, until now, compatable (i.e., viewable as two-dimensional, without glasses) home reception of 3-D images was not possible. However, a new system, which takes advantage of differential processing of left- and right-eye images in the human perceptual system, delivers a composite image on a standard home television reciever that can be viewed as a normal 2-D picture without glasses. Very inexpensive glasses, with one light and one dark lens, accentuate the differential processing of the image, as viewed by each eye, to produce a 3-D depth effect.

Practical, inexpensive, compatable (with standard TV) 3-D television may now become widespread. In addition to materials specifically produced for the new system (or other 3-D systems) conversion of standard 2-D programs to 3-D format would provide additional product to broadcast using the new compatable system (or for other 3-D projection systems).

SUMMARY OF THE INVENTION

Applicant Handal's previous application, number 479,679, filed March 28, 1983 and now abandoned, relates a process and apparatus for deriving left- and right-eye pairs of binocular images, from certain types of two dimensional film materials. In particular, the materials must consist of seperate foreground and background elements, such as cartoon animation cells and background art. By taking into account the parallax between scenes as viewed by the

left and right eyes, two images are prepared where foreground elements are shifted with respect to background elements by an amount that indicates their depth in the third dimension. Two-dimensional motion pictures that consist of a series of single composite images could not be converted to three-dimensional format, by this technique, without first being seperated into various background and foreground elements.

Once committed to two-dimensional motion pictures, the seperation and depth information for various scene elements, in the third dimension, are lost. Thus, the seperation of two-dimensional image sequences into individual image elements and the generation of three-dimensional depth information for each such image element are not simple or trivial tasks, and are the further subject of the instant invention.

In accordance with the invention, standard two-dimensional motion picture film or videotape may be converted or processed, for use with three-dimensional exhibition or transmission systems, so as to exhibit at least some three-dimensional or depth characteristics. Seperation of a single 2-D image stream into diverse elements is accomplished by a computer assisted, human operated system. (If working from discrete 2-D film sub-componants, such as animation elements, the seperation step may be ommited.) Depth information is assigned to various elements by a combination of human decisions and/or computer analyses and resulting images of three-dimensional format are produced under computer control.

BRIEF DESCRIPTION OF DRAWINGS

A method for carrying out the invention is described in the accompanying drawings in which:

Figure 1 is a diagram illustrating the relationship of a 2-D source film image, left and right image pairs, and a composite 3-D image frame.

Figure 2 is a schematic diagram of a system for carrying out an implimentation of the present invention.

DETAILED DESCRIPTION

An immense amount of standard, 2-D motion picure material exists in the form of film and videotape. In addition, certain materials exist in the form of discrete 2-D image sub-componants, such as animated cell and background paintings. As the use of 3-D exhibition and broadcast systems becomes more widespread, the conversion of existing 2-D programs to a format that will exhibit at least some 3-D or depth effects, when used with 3-D systems, is desired.

Extracting individual image elements or 3-D depth information from a 2-D film frame, or synthesizing 3-D information for those elements, entirely by computer equiped with artificial intelligence, is not now practical. Therefore, the embodiment of the invention as described herein employs a high degree of human interaction with the computer. However, as artificial intelligence progresses, a predominantly or completely automated system may become practical and is within the intended scope of the invention.

Figure 1 shows a frame 20 of a standard 2-D film or video motion picture, consisting of a cross-hatched background plane 21, a large white circle 22 in the mid-ground, and a small black square 23 in the foreground. It is a 2-D representation of original 3-D scene 10 comprising elements 11, 12 and 13, which is not

available for direct 3-D photography. After human identification of individual image elements and depth assignment, the computer generates, from frame 10, a pair of coordinated left 30 and right 40 images with backgrounds 31 and 41, circles 32 and 42, and squares 33 and 43 respectively. Note that the relative positions of the square and circle are different in the left and right images; this situation is similar to the parallax that might result between left- and right-eye views if one were to have viewed the original scene 10 directly. Three-dimensional format frame 50 is generated by encoding the information in the left 30 and right 40 image pair, in a manner consistent with any one of a number of existing 3-D systems. The specific operation of these various 3-D systems is not the subject of the instant invention.

Alternately, the steps of generating and encoding 3-D information may be combined such that 3-D format frame 50 may be processed directly from 2-D frame 20 without generating left 30 and right 40 image pairs. In either case, 3-D format frame 50 when viewed by human 60 through 3-D glasses 70 is perceived as 3-D scene 80, containing elements 81, 82 and 83, which has at least some of the 3-D characteristics of original 3-D scene 10.

Various systems for the encoding, display, projection, recording, transmission or viewing of 3-D images exist, and new sysems may be developed. Specifically, various techniques for specifying, encoding and viewing 3-D information may now, or come to, exist, which do not make use of parallax offset and/or left and right image pairs and/or viewing glasses, or which embody new techniques or changes and improvments to current systems. Further, such systems may integrate information from more than one 2-D source frame 20 into a single resultant 3-D frame 50. The specifics of operation of such systems is not the subject of the instant invention, however, preparation of 2-D program material for such systems is.

The offsets shown for elements 31, 32 and 33 in left frame 30 and elements 41, 42 and 43 in right frame 40 are meant to be illustrative and do not necessarily follow the correct rules for image parallax. In fact, depending upon where viewer attention is meant to be centered, different rules may apply. For example, one technique is to give no parallax offset to far background elements and to give progressively more parallax offset to objects as they get closer. Alternately, attention may be centered in the mid-ground with no parallax offset to mid-range objects, some parallax offset to close-range objects and reverse parallax offset to far-range objects. The particular placement of objects and attention point in the 3-D scene is as much an art as a science and is critical to the enjoyment of 3-D programs and, in any event, is not meant to be the subject of this invention.

Figure 2 shows a schematic of a system to implement the instant invention. A 2-D film or video image 10 is input to a video monitor 20 and to the scanning portion 41 of frame buffer 40. Video monitor 20 is capable of displaying either the 2-D image being input 10 or the output from display portion 42 of frame buffer 40.

Frame buffer 40 consists of an image scanner 41 which can convert the input image into digital form to be stored in a portion of frame buffer memory section 44, a display section 42 which creates a video image from the contents of a portion of memory section 44, and a computer interface section 43 which allows the computer CPU 50 to read from and write to the memory section 44.

Graphic input tablet 30 and stylus 35 allow the human operator to input position information to the computer 50 which can indicate the outline of individual image elements, choice of a specific image element or part of an image element, depth specification, choice of one of a number of functions offered on a 'menu', or other information. An image cursor can be displayed on monitor 20

by frame buffer 40 to visually indicate the location or status of the input from the tablet 30 and pen 35. Text and numeric information can also be input by the operator on keyboard 55.

Computer CPU 50 is equiped with software which allows it to interpret the commands and input from the human operator, and to process the digitized 2-D information input from 2-D frame 10 into digital 3-D frame information, based on said human commands and input. Said digital 3-D frame information is then output by output interface 60 (which may be similar to frame buffer 40 or of some other design) to a videotape recorder 70 or to a film recorder 75, capable of recording 3-D format frames.

The system as described above operates as follows. A frame of the 2-D program is displayed on the video monitor for viewing by the human operator. With the tablet and stylus the operator outlines various 2-D image areas to indicate to the computer the boundaries of various image elements to be seperately processed. (For materials, such as animation componants, that already exist as seperate elements, the previous stage of the process may be skipped.) Depth position information, in the third dimension, is determined for each image element, by a combination of operator input and computer analysis. Left and right image pairs or a 3-D composite image is processed by the computer, from the 2-D input image, based on the computer software and operator instructions. Depending upon the particular 3-D system to be used, left- and right-image pairs may or may not be the final stage or an imtermediate stage or bypassed entirely. Further, for some 3-D systems, information from more than one 2-D source frame may be combined into one 3-D frame (or frame pair). In any event, the final 3-D information is then collected on a videotape or film recorder. The process is then repeated for additional 2-D frames.

Each image element may be given a uniform depth designation which may cause the perception of 'cardboard cut-out' characters.

Alternately, different portions of a single image element may be given different depth designations with the computer interpolating depth coordinates over the entire element. For example, an image element positioned diagonally in a frame may have its right edge designated to be closer than its left edge. Alternately, one feature of an image element, say a person's nose in a close-up, might be designated as being closer than the rest of the image element. In such manner, the computer would be instructed to interpolate and process depth information over the entire image element. Such processing of the image element, in accordance with varying depth information, may result in the stretching, skewing or other distortion of the image element.

Depth interpolation may also be carried out over time, between frames. For example, an image element might be designated to be close in one frame and to be far away in a later frame. The depth of the image element may be interpolated for the frames between the two designated frames. Further, the position of the image element in the two dimensions of the film frame, and the shape of the outline seperating the image element from the rest of the source image, may also be interpolated over time, between frames. Linear and non-linear interpolation techniques are well known and may be readily applied.

It is also possible to add random noise to the depth information to eliminate the appearance of flat objects moving in space and to help achieve greater realism.

For a particular image element, depth position may be derived by the computer, alone or with operator input, by measuring the size of the image element in a frame. For example, once a person were outlined, his overall height in the 2-D film frame might be extracted by the computer as an indication of depth distance. Using knowledge, or making assumptions, about the object's real size, and the characteristics of the camera and lens, the

distance of the object from the camera may be calculated by applying well known principles of perspective and optics. Alternately, if overall size cannot be easily extracted by the computer, key points might be indicated by the operator for the computer to measure. Comparing the change of size of an image element in several frames will provide information about the movement of the object in the third dimension.

It should be noted that horizontal parallax offsets are, by far, more obvious, due to the fact that our eyes are seperated in the horizontal direction. However, vertical offset differences between left- and right-eye views may also be appropriate.

As various image elements are seperated and assigned depth values, a situation develops where diverse objects exist in a 'three-dimensional space' within the computer. It should be noted that, in order to display a realistic representation of the entire scene, fowardmost objects must obscure all or part of rearmost objects with which they overlap (except in the case where a fowardmost object were transparent). When generating left- and right-eye views, the pattern of overlap of image elements, and thus the pattern of obscuring of image elements will, in general, be different. Further, for image elements that have been assigned non-uniform depth values (e.g., image elements that are not flat or not in a plane perpendicular to the third dimension) the intersection between these image elements, for the purpose of one obscuring the other, may be non-trivial to calculate. However, there are well known techniques, that have been developed for computer image synthesis, that allow for the sorting, intersection and display of diverse, overlapping 3-D image elements.

As image elements are seperated from background scenes or each other, holes may develop. The computer software will compensate for this by filling in missing information in one particular 2-D

frame with the equivalent part of the image element from earlier or later frames whenever possible. Alternately, material to 'plug holes' may be created by the operator or by the computer from adjacent areas or may be newly synthesized. Further, as two image elements are seperated from each other, the fowardmost of the two may be moved closer to the viewer; hence, it may be appropriate to make it larger. Thus, the increased size may cover the gaps in the rearmost element of the two.

As part of the processing to be performed on the 2-D source image, individual image elements or composite images, additional effects may be programmed into the computer to heighten the sense of depth. For example, shadows cast by one image element on another element or the background may be calculated and inserted; far distant landscape elements may be made hazy or bluish to indicate remoteness; different image elements may be blurred or sharpened to simulate depth-of-field; or, the distance between close objects may be exagerated to emphasize their seperation. There are, of course, other technical or artistic techniques that can be used to indicate depth in an image and which may also be incorporated into the image processing programs and would therefore be part of the invention as described herein. Therefore, the above examples are illustrative and should not be construed as limiting the scope of the invention. Alternately, depth information may be intentionally distorted for effect or for artistic purposes.

Improvments may be made to the final product by including new image elements that were not part of the original 2-D source image. These could include 2-D image elements that are then assigned depth values, 3-D image elements created by 3-D photography and then entered into the computer as left- and right-image pairs, for example, or synthetic 3-D computer generated graphics. In particular, since computer generated image elements can be created with depth information, they can be

easily integrated into the overall 3-D scene with vivid effect. For example, a 3-D laser blast could be created by computer image synthesis such that it would in turn obsure and be obscured by other image elements in an appropriate maner, and might even be created so as to appear to continue beyond the front of the screen into 'viewer space'.

Animated film componants usually have relatively few background paintings, which are kept seperate from the animated characters in the foreground. For these, or for live 2-D filmed scenes, once the foreground elements have been seperated from the background, the flat 2-D backgrounds may be replaced by 3-D backgrounds. The 3-D backgrounds might consist of computer generated graphics, in which case depth information for the various elements of the background would be available at the time of the background creation. Alternately, 3-D backgrounds might be created using 3-D photography, in which case depth information for the background elements may be derived,, by the computer, from the comparison of the left- and right-image pairs of the 3-D background photographs and applying known image processing and pattern recognition techniques. Alternately, depth information to create 3-D backgrounds may be specified otherwise by operator input and/or computer processing. Once depth information is available for the various background elements, it may compared to depth information for the other image elements with which it is to be combined in each frame. Thus, the 3-D background may itself have some depth and, in effect, be a 'set' within which other image elements may be positioned in front of, behind or intersecting various background elements for added realism.

It should be noted that, intended purpose and software algorithms aside, the design and operation of the 3-D conversion system described herein has many similarities with the black & white footage colorization system described in applicant Geshwind's patent 4,606,625. They are both computer-aided systems which

display standard film images to an operator, allow the operator to input information seperating various image elements within the frame, allow the operator to specify attributes (color in one case, depth in the other) for the image elements, and cause the computer to process new image frames from the original, based on the operator input. Thus, the processing of 2-D black and white footage to add both color and depth information would be much more efficient than implementing each process seperately.

The scope of the instant invention is the conversion or processing of 2-D program material for use with any 3-D exhibition or distribution system now in use or later developed, but not the specific method of operation of any particular 3-D system.

It will thus be seen that the objects set forth above, among those made apparent from the proceeding description, are efficiently attained and certain changes may be made in carrying out the above method and in the construction set forth. Accordingly, it is intended that all matter contained in the above description or shown in the accompanying figures shall be interpreted as illustrative and not in a limiting sense.

Now that the invention has been described, what is claimed as new and desired to be secured by Letters Patent is: